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REPORT

ON

GREEN LAKE

KING COUNTY

WASHINGTON

EPA REGION X

WORKING PAPER NO. 868

WITH THE COOPERATION OF THE

WASHINGTON DEPARTMENT OF ECOLOGY

AND THE

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JULY, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT ON GREEN LAKE

KING COUNTY, WASHINGTON

EPA REGION X

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

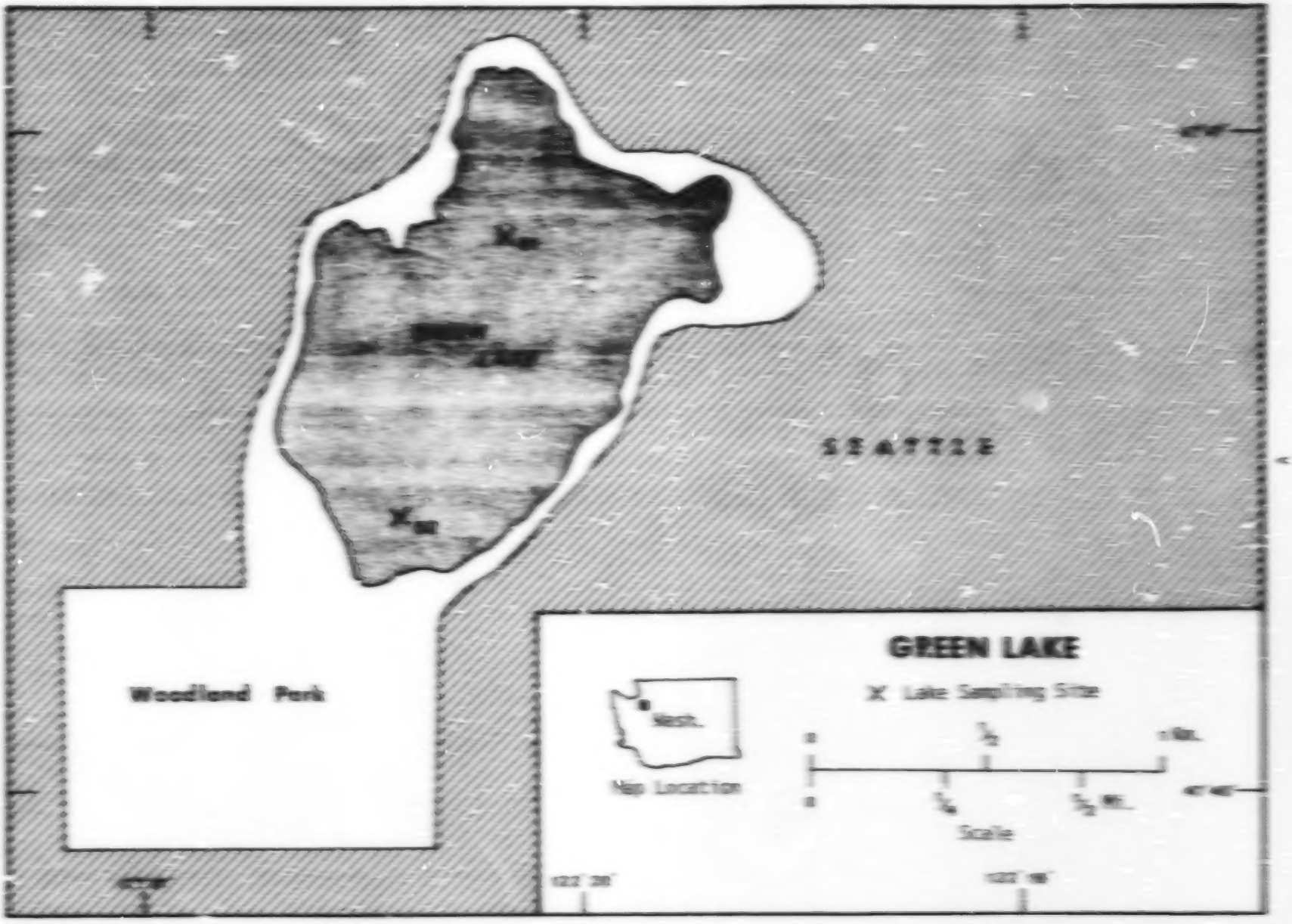
The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Washington Department of Ecology for professional involvement, to the Washington National Guard for conducting the tributary sampling phase of the Survey, and to those Washington wastewater treatment plant operators who provided effluent samples and flow data.

Ms. Barbara Blau, Lake Restoration Program, and the staff of the Washington Department of Ecology, Lake Restoration Program, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

Major General Howard S. McGee, Adjutant General of Washington, and Project Officer Colonel Clinton C. Johnson, who directed the volunteer efforts of the Washington National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES
STATE OF WASHINGTON

LAKE NAME	COUNTY
American Lake	Pierce
Banks Lake	Grant, Douglas
Chelan Lake	Chelan
Diamond Lake	Pend Oreille
Green Lake	King
Keechelus Lake	Kittitas
Mayfield Lake	Lewis
Medical Lake	Spokane
Moses Lake	Grant
Ozette Lake	Clallam
Sammamish Lake	King
Lake Whatcom	Whatcom
Lower Granite Reservoir	Garfield, Whatcom


SEATTLE
Woodland Park
GREEN LAKE
X Lake Sampling Site
Wash.
Map Location
Scale

REPORT ON GREEN LAKE, WASHINGTON
STORET NO. 5305

I. INTRODUCTION

Green Lake was included in the National Eutrophication Survey (NES) as a water body of special interest to the Washington State Department of Ecology. Tributaries and nutrient sources were not sampled, and this report relates only to lake sampling data.

II. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that Green Lake is eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake. Chlorophyll a values in the lake ranged from 0.4 µg/l in April to 5.5 µg/l in July, with a mean of 3.0 µg/l. Potential for primary productivity as measured by algal assay control yields was high. Of the 13 Washington lakes sampled in 1975, 3 had higher median total phosphorus values (0.027 mg/l), 10 had higher median inorganic nitrogen values (0.050 mg/l) and 5 had higher median ortho-phosphorus levels (0.009 mg/l) than Green Lake.

*See Appendix C.

Survey limnologists reported some emergent and floating macrophytes during the July sampling, and submerged weeds were noted during October. Ketelle and Uttormark (1971) report that although Green Lake is naturally eutrophic, the addition of low nutrient city water to the lake has resulted in improved water quality and fewer nuisance blue-green algal blooms.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Green Lake was limited by available phosphorus during the spring (04/01/75) and autumn (10/29/75) samplings. Lake data suggest nitrogen limitation in the spring and summer and phosphorus limitation in the fall.

III. LAKE CHARACTERISTICS

A. Lake Morphometry:*

1. Surface area: 1.04 km^2.
2. Mean depth: 3.8 meters.
3. Maximum depth: 9.8 meters.
4. Volume: 3.952 x 10^6 m^3.

B. Precipitation:

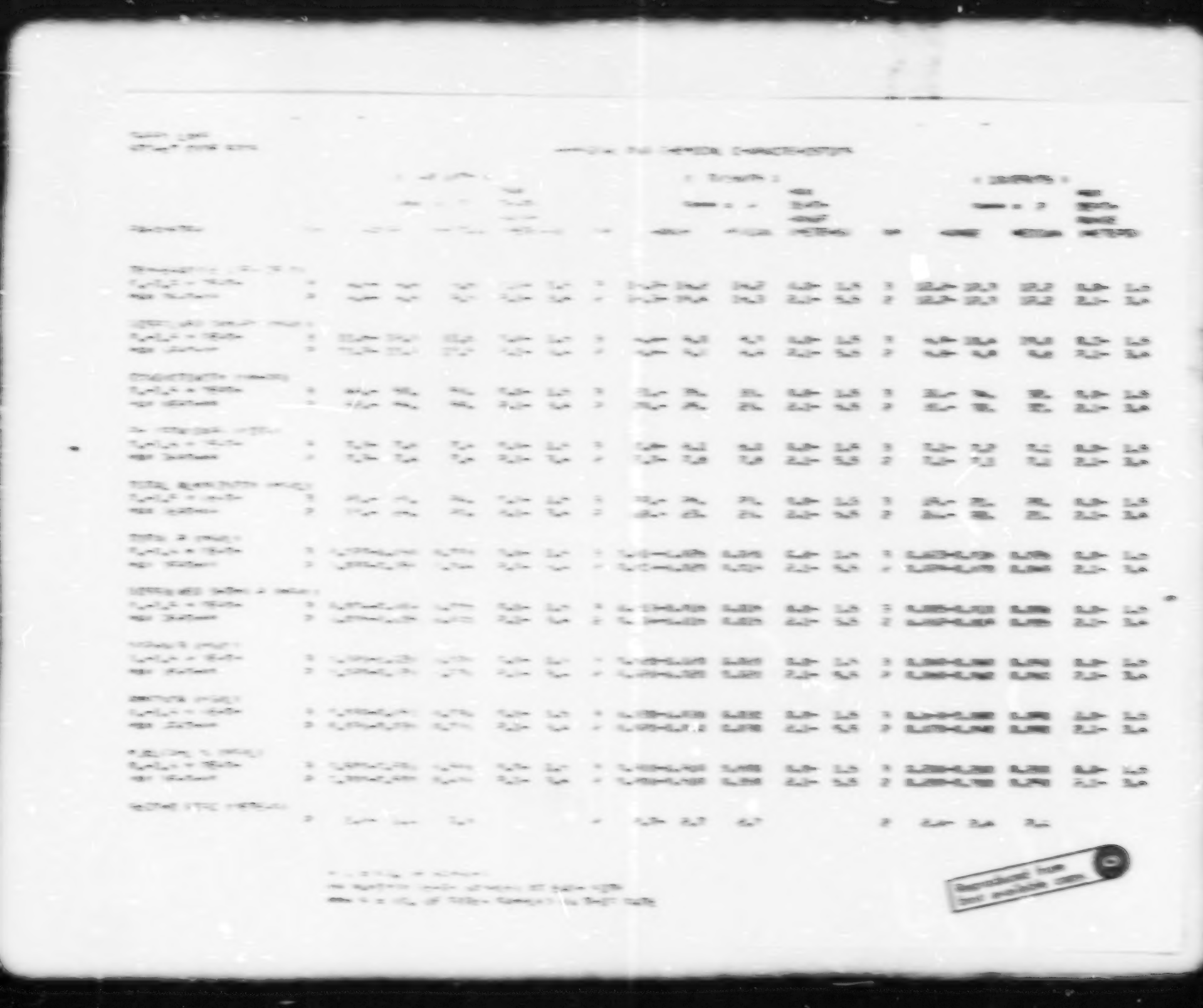
1. Year of sampling: 109.6 cm.
2. Mean annual: 90.6 cm.

*Ott, Charles R., 1960.

IV. LAKE WATER QUALITY SUMMARY

Green Lake was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 5.5 meters at Station 01, and 3.4 meters at Station 02. For a more detailed explanation of PLS methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix B and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.



B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/01/75	1. Asterionella	3,960
	2. Aphanizomenon	2,467
	3. Fragilaria	1,301
	4. Flagellate	287
	5. Centric Diatom	57
	Other genera	192
	total	8,264
07/16/75	1. Microcystis	341
	2. Oscillatoria	341
	3. Cyclotella	189
	4. Chroomonas	114
	5. Closterium	38
	Other genera	37
	total	1,060
10/29/75	1. Asterionella	676
	2. Chrysophyta	204
	3. Anabaena	157
	4. Fragilaria	157
	5. Aphanizomenon	94
	Other genera	158
	total	1,446

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
04/01/75	01	0.6
	02	0.4
07/10/75	01	2.0
	02	5.5
10/29/75	01	4.5
	02	4.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 04/01/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.009	0.044	0.8
0.05 P	0.059	0.044	3.6
0.05 P + 1.0 N	0.059	1.044	20.6
1.00 N	0.009	1.044	0.8

b. 10/29/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.140	2.9
0.05 P	0.060	0.140	6.1
0.05 P + 1.0 N	0.060	1.140	30.5
1.00 N	0.010	1.140	3.5

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential for primary productivity in Green Lake was moderate during spring sampling (04/01/75) and high at the time of autumn sample collection (10/29/75). In both assays, a significant increase in yield over that of the control occurred when phosphorus was added alone and in combination with nitrogen, indicating phosphorus limitation. The addition of nitrogen alone did not produce a significant growth increase beyond that of the control.

The mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were approximately 11/1, 3/1, and 24/1 in the spring, summer, and fall, respectively, suggesting primary limitation by nitrogen in the spring and summer, and phosphorus limitation in the fall (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

V. LITERATURE REVIEWED

Ketelle, Martha J. and Paul O. Uttormark. 1971. Problem Lakes in the United States. U.S. Environmental Protection Agency Project #16010ECM. University of Wisconsin, Madison, Wisconsin.

Ott, Charles R. 1960. A Study of the Environmental Factors Affecting the Eutrophication of Green Lake. MS Thesis, Civil Engineering Department, University of Washington, Seattle, Washington.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
PHYSICAL AND CHEMICAL DATA

[illegible]

APPENDIX C

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF WASHINGTON

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Washington lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in µg/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

[illegible] DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SUS- [illegible] SEC	[illegible] CHLOR	25- [illegible] DO	[illegible] SECCHI DEPTH M
5301	[illegible] LAKE	0.027	0.195	343.000	4.822	15.000	0.007
5302	[illegible] LAKE	0.021	0.040	364.533	7.373	10.000	0.007
5303	CHELAN LAKE	0.005	0.070	111.900	0.605	6.400	0.003
5304	[illegible] LAKE	0.014	0.060	303.667	14.537	14.200	0.010
5305	[illegible] LAKE	0.027	0.050	415.000	2.903	10.400	0.004
5306	[illegible] LAKE	0.007	0.040	200.250	1.400	9.200	0.002
5307	[illegible] LAKE	0.014	0.170	402.000	4.250	10.400	0.007
5308	[illegible] LAKE	0.375	0.225	491.714	10.425	15.000	0.146
5309	[illegible] LAKE	0.115	0.250	443.600	29.040	14.600	0.030
5310	[illegible] LAKE	0.010	0.110	413.333	1.225	7.200	0.004
5311	[illegible] LAKE	0.015	0.210	374.700	7.240	14.600	0.004
5312	[illegible] LAKE	0.009	0.307	294.000	3.427	10.400	0.004
5313	[illegible]	0.033	0.150	435.500	4.875	7.200	0.022

| | | |